Slopewater Currents in the Middle-Atlantic Bight and Associated Coupling to the Shelfbreak Circulation: Analysis of the Shelfbreak Primer Data Set

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Award Number: N00014-98-1-0046

LONG-TERM GOALS

The long-range goal of the Shelfbreak PRIMER is to gain a better understanding of the variability, forcing and associated dynamics of the shelfbreak current, which in turn will clarify the factors governing the propagation of sound across the shelfbreak front. One of the premises of the experiment is that the shelfbreak jet does not evolve in isolation, but is strongly influenced by the adjacent slopewater circulation.

OBJECTIVES

The main objectives of the slopewater component of the PRIMER experiment are (1) to determine the mean and fluctuating currents/water-masses on the continental slope in the Middle-Atlantic Bight, and (2) to elucidate the nature of the mesoscale variability — in particular to understand the coupling between the slopewater currents and shelfbreak circulation.

APPROACH

The Shelfbreak PRIMER is a joint experiment addressing the acoustics/physical oceanography of the shelfbreak front and adjacent slopewater in the Middle-Atlantic Bight. The field work was undertaken over a two-year period from December 1995 to December 1997. The slopewater component of PRIMER consisted of long-term moored observations across the shelfbreak (upward-looking ADCPs) and continental slope (VACMs) supplemented by repeat hydrography. In all, five CTD slope sections were occupied during the two-year VACM deployment, and six high-resolution shelfbreak CTD sections were done during the 15-month ADCP deployment.

During the course of these long-term measurements, a pair of short-term intensive field studies were carried out at the shelfbreak as part of the Acoustic and SEASOAR components of PRIMER (there was also a SEASOAR pilot-test survey). These consisted of detailed SEASOAR mapping of the shelf-break current, concurrent acoustical measurements across the front, and short-term mooring deploy-ments.

WORK COMPLETED

In total, the slopewater component consisted of five cruises over the course of two years in which nearly 200 CTD stations were occupied and two separate moored arrays maintained. All hydrography was done using NBIS Mark III instruments, calibrated both in the laboratory and with *in-situ* water

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
1998		**00-00-1998 to 00-00-1998**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Slopewater Currents in the Middle-Atlantic Bight and Associated Coupling Shelfbreak Circulation Analysis of the Shelfbreak Primer Data Set	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Woods Hole Oceanographic Institution,Department of Physical Oceanography,Woods Hole,MA,02543**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM002252.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**4**	

samples (the latter of which was crucial for the deep slope stations). Shipboard ADCP data were collected on all cruises. At this point all the data (moored, hydrographic, shipboard) are fully processed, with the exception of the December CTD stations which will be completed shortly. The only significant hydrographic data gap occurred during the last cruise when the shelfbreak section was aborted due to unfavorable weather. However, this section was occupied two extra times during the course of PRIMER on "cruises of opportunity," resulting in six such shelfbreak sections spanning all seasons. The only gap in the mooring records is for the onshore shelfbreak ADCP, where the instrument malfunctioned for a six-month period. It is worth noting, however, that obtaining the remaining nine months of data — as well as the full 15-month record for the offshore ADCP — was quite an achievement. Both of the these moorings were located in a region of intense fishing activity, and twice we needed to make emergency cruises to replace guard buoys and/or find instruments which were dragged off location.

As of January 1998 we have begun the analysis of the PRIMER data set, focusing first on shelfbreak hydrography and moorings.

RESULTS

As described in last years report, we completed a study of the structure and dynamics of a shelfbreak jet meander. A manuscript is now in press (Pickart *et al.*, 1998). Presently we are immersed in two additional studies of the shelfbreak jet: the first concerning the bottom boundary layer, and the second addressing jet variability.

Bottom Boundary Layer Structure And Detachment

This study addresses the characteristics and structure of the bottom boundary layer (BBL) in the springtime 1996 section. Our data show that the BBL height is a minimum across the shelfbreak front (disappearing altogether at the shoreward edge of the front). The vertical stratification of the BBL is nearly zero everywhere, except in this region of minimum height where there are substantial vertical gradients in T, S, and σ_θ. We are presently trying to explain this distribution and its relationship to the interior flow. Numerical modeling studies predict that the offshore flow in the BBL should "detach" upon reaching the foot of the shelfbreak front (Gawarkiewicz and Chapman, 1992; Chapman and Lentz, 1994), and subsequently flow into the interior along an isopycnal. We have identified such a detached layer located above the shelfbreak front, emanating from the BBL. This density layer is recognizable both by its low stratification (minimum in $d\sigma_\theta/dz$) as well as reduced lateral gradients in temperature and salinity (presumably due to the enhanced cross-stream advection in the detached BBL, Figure 1). Among the issues being pursued is, what happens to the layer when it encounters the shelfbreak jet?

Shelfbreak Jet Structure And Variability

This study involves analysis of the shelfbreak jet moorings as well as the numerous vessel-mounted ADCP crossings. The mean vectors indicate that both moorings were located within the jet, although there is significant variability on a variety of time scales. We are presently trying to explain the nature and cause of this variability. An immediate question is, are such fluctuations simply due to lateral translations of a "rigid" jet? In order to help answer this question we are constructing an average synoptic velocity section of the jet using roughly 50 vessel-mounted ADCP crossings taken over the

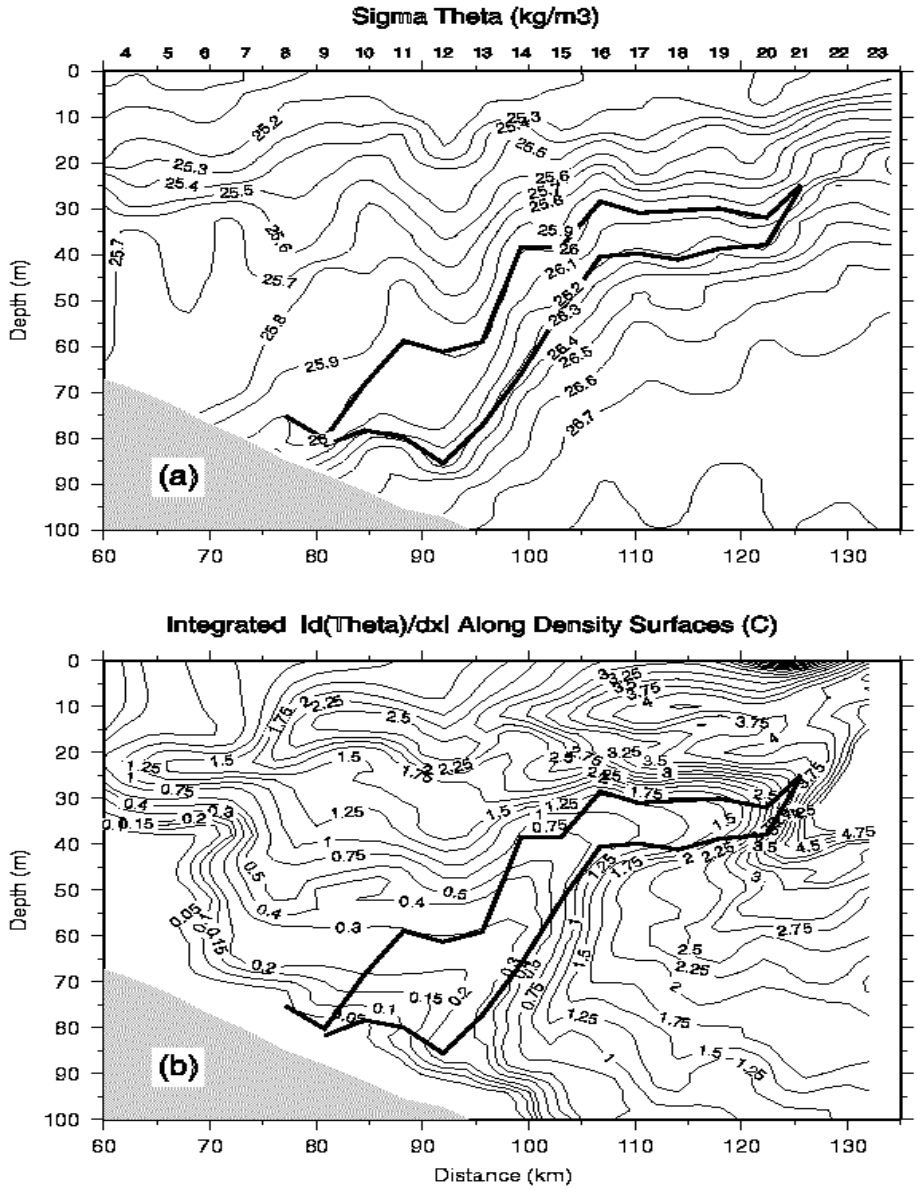

Figure 1: (a) Potential density of the shelfbreak front. The thick lines denote the detached BBL as revealed by a minimum in stratification. (b) Integral of |d(Theta)/dx| along density surfaces, starting from the inshore side of the section. The tongue of low values also reveals the separated BBL.

two-year PRIMER period. Such a mean has never been computed, and it is unclear as to even what the basic structure will be.

IMPACT

Our technique for identifying the detached BBL is significant in that it uses only the physical *T,S* data (*i.e.*, the technique can be applied to any CTD section). Up until now such information could only be obtained from special tracers (*e.g.*, Barth *et al*., 1998) or purposeful dye releases (Houghton and Visbeck, 1998). We will analyze the two separate week-long SEASOAR surveys of the front to determine the morphology of the BBL and its space–time evolution. Our mean synoptic shelfbreak jet velocity section will be of use to various modeling studies of the front.

TRANSITIONS

None

RELATED PROJECTS

The shelfbreak PRIMER is by design a collaborative effort between acousticians and physical oceanographers (including both observations and modeling). The communication between the different PIs has been excellent, and there are numerous joint projects presently underway (*e.g.*, the BBL study described above using the SEASOAR data). A PRIMER workshop is scheduled for early 1999.

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